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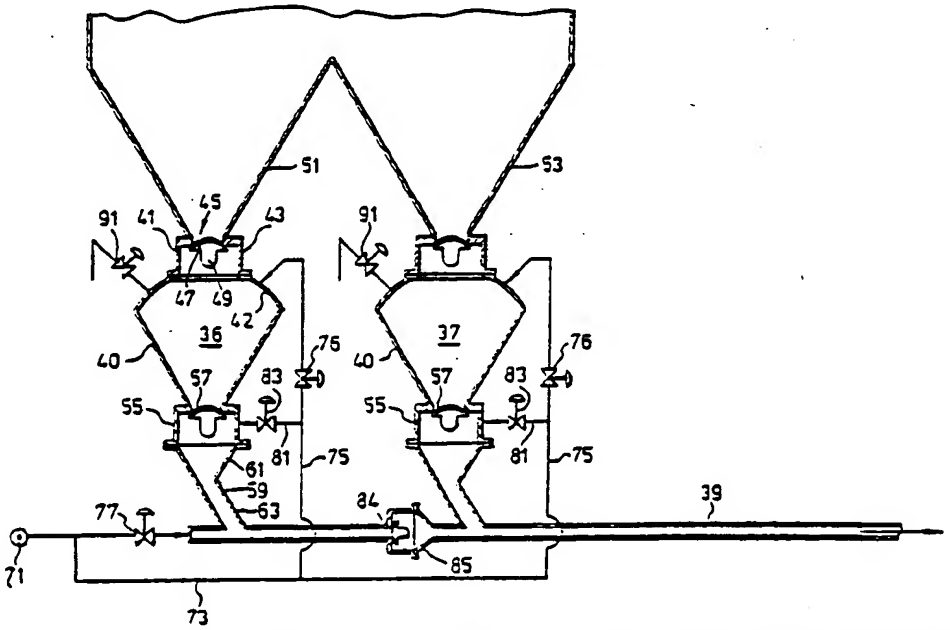

(57) Abstract

Apparatus for conveying bulk granular material includes a pipeline (39) into which are connected a plurality of material feed members (36, 37). Each material feed member has a material inlet valve (41) and a material outlet valve (55) both of which are closable to prevent passage therethrough of both material and compressed gas. The apparatus is provided with means (71, 73, 75, 76) for feeding compressed gas to each material feed member in order to assist the discharge of material into the pipeline. The opening and closing of the valve is controllable so that at least one of the material feed members may be filled with material while at least one other of the material feed members is discharging material into the pipeline. A method for conveying bulk granular material is also described.

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CONVEYING OF BULK MATERIALS

This invention relates to the conveying of bulk materials and in particular to apparatus and methods for the pneumatic conveying of bulk granular or particulate materials from one site to another site along a pipeline.

Previously material handling apparatus for conveying granular, abrasive or cohesive materials such as sand, coal, or ash and grit from boilers, from a plurality of sites to one or more destinations has involved a separate pipeline from each site to the destination of the material from that site. The material is fed into the pipeline and is sucked along the pipeline to its destination. Alternatively a single pipeline has been provided with a continuous high velocity gas stream passing through the pipe, material being fed into the airstream by a plurality of inlet devices, usually in the form of rotary valves. The ratio of material to air in the pipeline is comparatively low and the air moves along the pipeline, with the material entrained in the airstream, at a high velocity. As a result the conveying pipework is subject to considerable wear. Furthermore, wet or cohesive materials are not suitable for such high velocity pneumatic conveying

due to their tendency to form plugs and thereby to block the conveying pipe or for the material to build up on the internal surfaces of the pipework.

The above-mentioned problems can be overcome to some extent by using high pressure air to push material in batches along the pipeline. In this case the ratio of material to air is comparatively high. The material can be "loaded" into the pipeline at an inlet point, the inlet point then sealed to prevent escape of compressed air and material, and compressed air applied to the material to push it along the pipeline. However, for many materials it is found that it is not possible efficiently to load the material into the pipeline through a plurality of inlets and at the same time to push material so loaded along the pipeline. There is a tendency for material in the pipeline to stop moving when further material is loaded at the same or another point into the pipeline and for material to be moved in the opposite direction to that intended and even to be pushed back into one or other of the inlets.

According to the present invention there is provided apparatus for conveying granular material comprising a plurality of material feed members, each of said members being connected to a common pipeline and each having a material feed valve and a material outlet valve, both said valves being closable to prevent passage therethrough of both material and compressed gas, means for feeding compressed gas to each said feed member to discharge material into the pipeline, control means for operating said valves so that at least one of the material feed members may be filled with material while at least one other of said material feed members is discharging material into

the pipeline.

Apparatus in accordance with the present invention provides material feed members which may be in the form of chambers located adjacent the pipeline, each chamber being openable at an upper part thereof to admit material into the chamber and also openable at a lower part to enable material to be discharged into the pipeline. Accordingly, each chamber can be isolated from the pipeline and when so isolated may be filled with material while one or more further chambers are emptying material into the pipeline.

One application of apparatus in accordance with the present invention is the conveying of coal on coal fired ships. The coal is stored in fuel bunkers and apparatus in accordance with the present invention allows the coal to be conveyed from the fuel bunkers to the hoppers which feed the coal to the ships' boilers. Previously coal handling on coal fired ships has involved the use of mechanical drag link conveyers or belt conveyers and bucket elevators. Such mechanical systems are difficult to automate, are high in maintenance requirements and are liable to cause coal spillage along the conveying path. For many years ships have operated with small crews and, therefore, all the systems on ships should be as fully automated as possible.

Coal bunkers provided on coal fired ships are liable to be large and to extend the full width of the ship. Apparatus in accordance with the present invention enables multiple outlets to be provided in the base of the or each coal bunker, the outlets feeding into a common pipeline thereby achieving a highly efficient system of conveying coal from the or each bunker to the boiler hoppers. Furthermore, by the

provision of multiple outlets the bunker or bunkers can be emptied in such a way as to keep the centre of gravity of the coal as low as possible and to ensure that the ship is always correctly balanced. Thus the system can be operated in a sequential manner to ensure that the coal level drops evenly as the coal is burnt. In this way the trim requirements of the ship are reduced to a minimum. In addition, the risk of spontaneous combustion, which is more likely to occur if coal in a particular portion of the bunker remains unused and is thereby not moved, is reduced to a minimum.

As mentioned above, means are provided for feeding compressed air to each said material feed member. In addition means may be provided for feeding compressed air to the pipeline itself at a position upstream of the material feed members. In another embodiment of the present invention a pipeline closure member may be located upstream of one or more of said material feed members in order to ensure that there is no material movement in the wrong direction along the pipeline.

Preferably each material feed member is provided with a venting valve to allow gas to escape from the material feed member when said member is being filled with material.

The material feed members may be connected to the pipeline at spaced apart positions along said pipeline. Alternatively the material feed members may be connected to the pipeline at a common position on the pipeline.

Apparatus in accordance with the present invention may be provided with means for introducing compressed gas to said material feed members at a position below said outlet valves in order to prevent

material lodging in said valves.

Preferably the inlet and/or outlet valve of each material feed member includes an annular seal adapted to be pushed against the valve member when said valve member is in a closed position. In this way the valve can be efficiently sealed to prevent passage therethrough of gas and particulate material. More preferably the inlet and/or outlet valve of each material inlet member includes a part-spherical closure member.

Apparatus in accordance with the present invention may be provided with material feed hoppers mounted for vibratory movement above the material inlet valve of each material feed member, means being provided for effecting such vibratory movements.

The present invention also provides a method for conveying bulk granular material comprising feeding said material along a plurality of material feed members, each of said members being connected to a common pipeline and each having a material inlet valve and a material outlet valve, both said valves being closable to prevent passage therethrough of both material and compressed gas, and feeding compressed gas to each said feed member to discharge material therefrom into the pipeline, the operation of said valve being controlled so that at least one of the material feed members is being filled with material while at least one other of said material feed members is discharging material into the pipeline.

In apparatus in accordance with the present invention or the use of a method in accordance with the present invention, the manner in which the filling and discharging of the material feed members is controlled will depend upon the rate at which material

is to be conveyed along the pipeline as well as the handling capabilities of the pipeline and the material feed members. Whether the arrangement is such that one material feed member is discharging into the pipeline while the or each other material feed member is being filled, or whether a plurality of material feed members are discharging simultaneously into the pipeline, the control can be such that a substantially continuous flow of material is provided along the pipeline.

Embodiments of the present invention will now be described, by way of examples only, and with reference to the accompanying drawings, in which:-

Figure 1 is a diagrammatic elevation of apparatus in accordance with the present invention forming a coal handling system for a coal fired ship;

Figure 2 is a plan of the apparatus of Figure 1;

Figure 3 shows part of an alternative arrangement for a coal handling system for a ship;

Figure 4 shows in detail part of the apparatus of Figure 1;

Figure 5 shows detail of a valve of one of the material feed chambers of Figure 4; and

Figure 6 shows detail of an alternative feed arrangement for apparatus such as that shown in Figure 1.

Referring to Figures 1 and 2 of the accompanying drawings, apparatus in accordance with the present invention is in the form of a coal handling system for a coal fired ship. The apparatus includes one or more coal storage bunkers 1 from which coal has to be conveyed to boiler hoppers 3 located in a remote part of the ship. Coal located in boiler hoppers 3 is transferred to boiler 5 where it is burnt.

The coal is fed from the coal storage bunkers 1 to boiler hoppers 3 along four pipelines 7. Each pipeline is fed with material from the coal storage

bunkers 1 via four material feed chambers 9. Each material feed chamber 9 is connected to a bunker 1 via hopper 11 and a vibratory feed shute 13.

Each material feed chamber 9 is provided with an upper material inlet valve and a lower material outlet valve which will be described in greater detail below. These valves and those of the other material feed chambers of the system are operated by a control system (not shown) so as to maintain a substantially continuous flow of material along the pipeline 7 and to empty the coal bunkers 1 so that the coal level drops substantially evenly across the bunkers.

Coal is fed along a particular pipeline 7 to a dump valve 15 mounted above one of the boiler hoppers 3. This dump valve is such that the coal may be directed from pipeline 7 into the hopper below the dump valve or alternatively it may be passed to pipeline 17 leading from a first hopper 3a to a second hopper 3b spaced laterally from first hopper 3a. At the end of pipe line 17 the coal enters a terminal box 19 which directs the coal downwardly into hopper 3b. Accordingly, the system allows coal to be directed along a particular pipeline to a coal bunker on one or the other side of the ship depending upon the level of coal in each hopper 3 and the boiler requirements. The positions of the valve members in dump valves 15 are controlled by control means (not shown) which may receive information from level probes located in hoppers 3.

Each hopper 3 is also provided with two filter units 21 which allow escape of air from the hopper as it is being filled but retain coal particles within the hopper.

In the above-described system a plurality (four)

of material feed chambers are connected in series at spaced apart positions along a particular pipeline 7.

Referring to Figure 3, an alternative arrangement is such that coal is delivered by a plurality of material feed chambers 23 along short pipelines 25 to a junction point 27 and thence into a common pipeline 29. Again the control means for the valves of material feed chambers 23 may be such as to ensure that material from one material feed chamber is not fed into junction point 27 at the same time as material from another material feed chamber 23 but that the feeds are staggered to result in a substantially continuous flow of material down common pipeline 29.

Referring to Figure 4, there is shown in greater detail part of a system in which two material feed chambers 36 and 37 are connected in series to a pipeline 39, this arrangement forming perhaps part of a system such as is shown in Figures 1 and 2. Each material feed chamber has a substantially conical shaped main wall portion 40, the upper wider end being closed by a dished shaped end member 42 having a large central aperture therein. Extending across the central aperture and also extending upwardly therefrom is inlet valve 41 having valve housing 43 which defines a circular inlet opening 45. Mounted within housing 43 is a part-spherical shaped valve member 47 which in turn is mounted for rotation about an axis 49 perpendicular to the plane of the drawing.

Detail of inlet valve 41 is shown in Figure 5. Valve housing 43 encloses diametrically oppositely disposed drive shaft 42 and pivot shaft 44. Drive shaft 42 extends outwardly beyond bearing arrangement 46 to an external drive motor 48. Both drive shaft 42 and pivot shaft 44 extend a short distance inwardly of the inner surface of housing 43. The inward end of drive shaft 42 and pivot shaft 44 are each attached to a

respective downwardly depending portion 50, 52 of valve member 47. The arrangement is such that the common axis of shafts 42 and 44 passes through the centre of the spherical shell of which closure member 47 forms a part. Rotation of drive shaft 42 by means of motor 48 causes valve member 47 to move from its closed position as shown in Figure 5 through 90° to its open position. The arrangement of the drive and pivot shaft 42 and 44 relative to the valve member 47 and the degree of movement of the valve member means that, when the valve member 47 is in its open position, the path of movement for material passing between hopper 51 and chamber 36 is entirely unrestricted by the valve member 47 or its driving arrangement.

When the chamber 36 is being filled with material, the valve member 47 will be in its open position. When it is desired to close the valve, it will normally be full of bulk granular material. During the closing movement the leading edge of the valve member 47 slices through the column of bulk material.

Formed in valve housing 43, adjacent valve member 47, is an annular recess 56. Located in recess 56 is an annular ring 58. Ring 58 is bonded to the walls of recess 56 except for the central portion thereof. Ring 58 is made of a flexible and resilient hard-wearing material. Extending through valve housing 43 from an exterior surface to recess 56 is a bore 60. At that end remote from recess 56 bore 60 leads into a connector 62 so that extending from connector 62 is a pipe 64 along which may be supplied compressed air. When valve member 47 is in its closed position, compressed air may be supplied along bore 60 to annular ring 58 at that side remote from valve member 47. The compressed air urges ring 58 into sealing contact with valve member 47. The arrangement is such that compressed

air will fill the whole of the small annular space in recess 56 behind ring 58 so as to press ring 58 against valve member 47 along the entire length of ring 58.

The surface of annular ring 58 which engages valve member 47 has a width such that any small particles which are trapped between ring 58 and valve member 47 will be entirely enclosed and will not affect the efficiency of the seal between the ring and valve member. Provided the air pressure in the space behind ring 58 is greater than the pressure difference across the valve member 47, then a gas-tight seal will be maintained across the valve.

Extending upwardly from the top surface of housing 43 is a conical hopper 51. Hopper 51 interconnects with hopper 53 located above material feed chamber 37 and the two hoppers 51 and 53 are integral with a large storage bunker such as bunker 1 shown in Figure 1.

At the bottom narrower end of material feed chamber 36 (or 37) there is mounted an outlet valve 55 which is similar in construction to inlet valve 41 and includes a part-spherical valve member 57. Connected to and extending downwardly from the outlet valve 55 is connection pipe 59 leading into pipeline 39. Connection pipe 59 includes an upper portion 61 which narrows from the position where it connects to outlet valve 55 to lower portion 63 which is a pipe of diameter comparable to the diameter of pipeline 39.

High pressure compressed air is supplied to the system from source 71. It is supplied along line 73 and 75, and via valves 76, to each of chambers 36 and 37, entering these chambers through the dome shaped upper portions 42 thereof. Compressed air from source 71 is also delivered directly to the end of pipeline 39, via valve 77, although such a feature may, if desired, be omitted from the system.

Compressed air may also be delivered, from each of

lines 75, to valve 55 at a position through the valve housing just below valve member 57 in its closed position. Such compressed air is fed along lines 81, via valves 83. However, in an alternative embodiment this feature may be omitted.

The material feed chambers 36 and 37 are also provided with venting valves 91 which allow air to be vented from the chambers when the chambers are being filled with material, the valves 91 being connected to the chambers at positions in the dome shaped upper portions 42 thereof.

Located in the pipeline 39 at a position just upstream of material feed chamber 37 is a pipeline closure valve 85 having a part-spherical closure member 87. This valve, which may be omitted, if desired, may be closed to prevent material which is being fed from chamber 37 to pipeline 39 from being blown along the pipeline in the wrong direction, that is to say, in a direction towards chamber 36.

The operation of the arrangement shown in Figure 4 may be as follows. Inlet valve 43 and venting valve 91 are opened and, with all other valves closed, material enters chamber 36. When chamber 36 is full valves 43 and 91 are closed. (In the case where valve 85 is furnished, this valve also is opened.) Then outlet valve 55 and air inlet valves 76 and 77 are opened. Air entering chamber 36 via valve 76 pushes material from chamber 36 into pipeline 39, the airflow being maintained until the plug of material reaches its destination at the other end of pipeline 39. At this time valves 76, 77 and 55 are closed. Valves 41 and 91 are now opened again to allow chamber 36 to be refilled, the sequence being repeated until coal has been transferred from hopper 51 to remotely sited boiler hoppers.

Compressed air entering pipeline 39 through valve

77 provides additional "push" of the coal along the pipeline. Compressed air may be allowed to enter valve 55 through line 81 of valve 83 in order to prevent material becoming lodged in valve 55.

The operation of the other material feed chamber 37, and its associated valves, is similar to that described above. (In the case where valve 85 is provided, a further air line to the housing of valve 85 may replace the supply of air to the pipeline via valve 77.) In practice, two chambers may be operated sequentially, chamber 37 being filled while material is being pushed into the pipeline from chamber 36 and vice versa. Air entering the pipeline directly through valve 77 acts, in the case where valve 85 is omitted, to prevent material entering pipeline 39 from chamber 37 from proceeding in the wrong direction along pipeline 39. In the case where valve 85 is provided, this valve will be open when material is being moved along the pipeline from chamber 36 and closed when material is being moved into the pipeline from chamber 37. In the latter case valve 85 then prevents material from moving in the wrong direction when it enters pipeline 39.

Referring to Figure 6, there may be located between a feed hopper 101 (similar to feed hoppers 51 and 53) and a material feed chamber 103 (and its associated inlet valve 105) a vibratory feeder 10a. The main body of vibratory feeder 107 is in the form of a [redacted] which at its upper end is connected to feed hopper 101 by means of flexible mountings 110 and flexible annular sleeve 111. A further flexible annular sleeve 113 interconnects the lower narrow end of chute 109 and valve 105. A vibrator motor 119 is connected to chute 109.

During the operation of the system and when inlet

valve 105 is open, the vibrator motor 119 is operated so as to vibrate chute 109. This movement of chute 109 breaks up the cohesive material so that its fall by gravity into chamber 103 is facilitated.

CLAIMS:

1. Apparatus for conveying granular material characterised in that the apparatus comprises a plurality of material feed members, each of said feed members being connected to a common pipeline and each having a material inlet valve and a material outlet valve, both said valves being closable to prevent passage therethrough of both material and compressed gas, means for feeding compressed gas to each said feed member to discharge material into the pipeline, and control means for operating said valves so that at least one of the material feed members may be filled with material while at least one other of said material feed members is discharging material into the pipeline.

2. Apparatus according to claim 1 characterised in that means are provided for feeding compressed air to the pipeline at a position upstream of said material feed members.

3. Apparatus according to claim 1 characterised in that a pipeline closure member is located upstream of one or more of said material feed members.

4. Apparatus according to any of the preceding claims characterised in that each material feed member is provided with a venting valve to allow gas to escape from the material feed member when said member is being filled with material.

5. Apparatus according to any of the preceding claims characterised in that the material feed members are connected to the pipeline at spaced apart positions along said pipeline.

6. Apparatus according to any of claims 1 to 4 characterised in that the material feed members are connected to the pipeline at a common position on the

pipeline.

7. Apparatus according to any of the preceding claims characterised in that means are provided to introduce compressed gas to said material feed members at a position below the closure members of said outlet valves in order to prevent material lodging in said valves.

8. Apparatus according to any of the preceding claims characterised in that the inlet and/outlet valve of each material feed member includes an annular seal adapted to be pushed against the valve member when said valve member is in a closed position.

9. Apparatus according to any of the preceding claims characterised in that the inlet and/outlet valve of each material feed members includes a part-spherical closure member.

10. Apparatus according to any of the preceding claims characterised in that a material feed hopper is mounted for vibratory movement above the material inlet valve of each material feed member, and means are provided for effecting such vibratory movement.

11. A method for conveying bulk granular material characterised in that the method comprises feeding said material into a plurality of material feed members, each of said members being connected to a pipeline and each having a material inlet valve and a material outlet valve, both said valves being closable to prevent passage therethrough of both material and compressed gas, and feeding compressed gas to each said feed member to discharge material therefrom into the pipeline, the operation of the valves being controlled so that at least one of the material feed members is being filled with material while at least one other of said material feed members is discharging material into the pipeline.

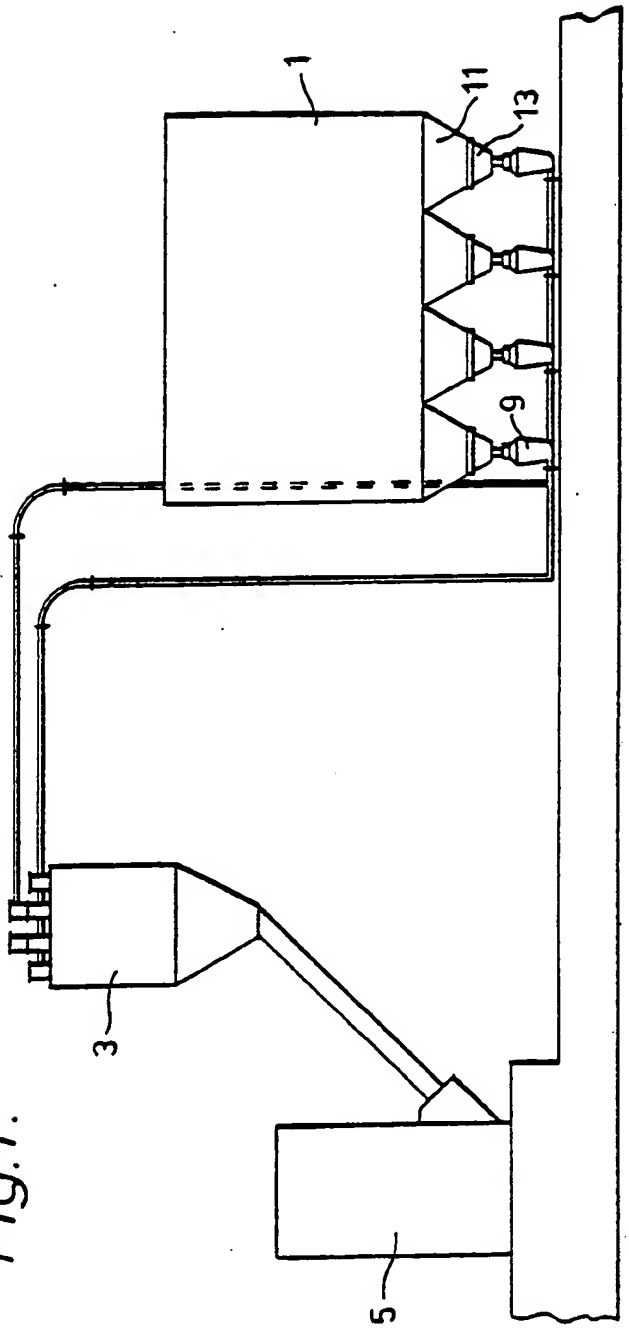
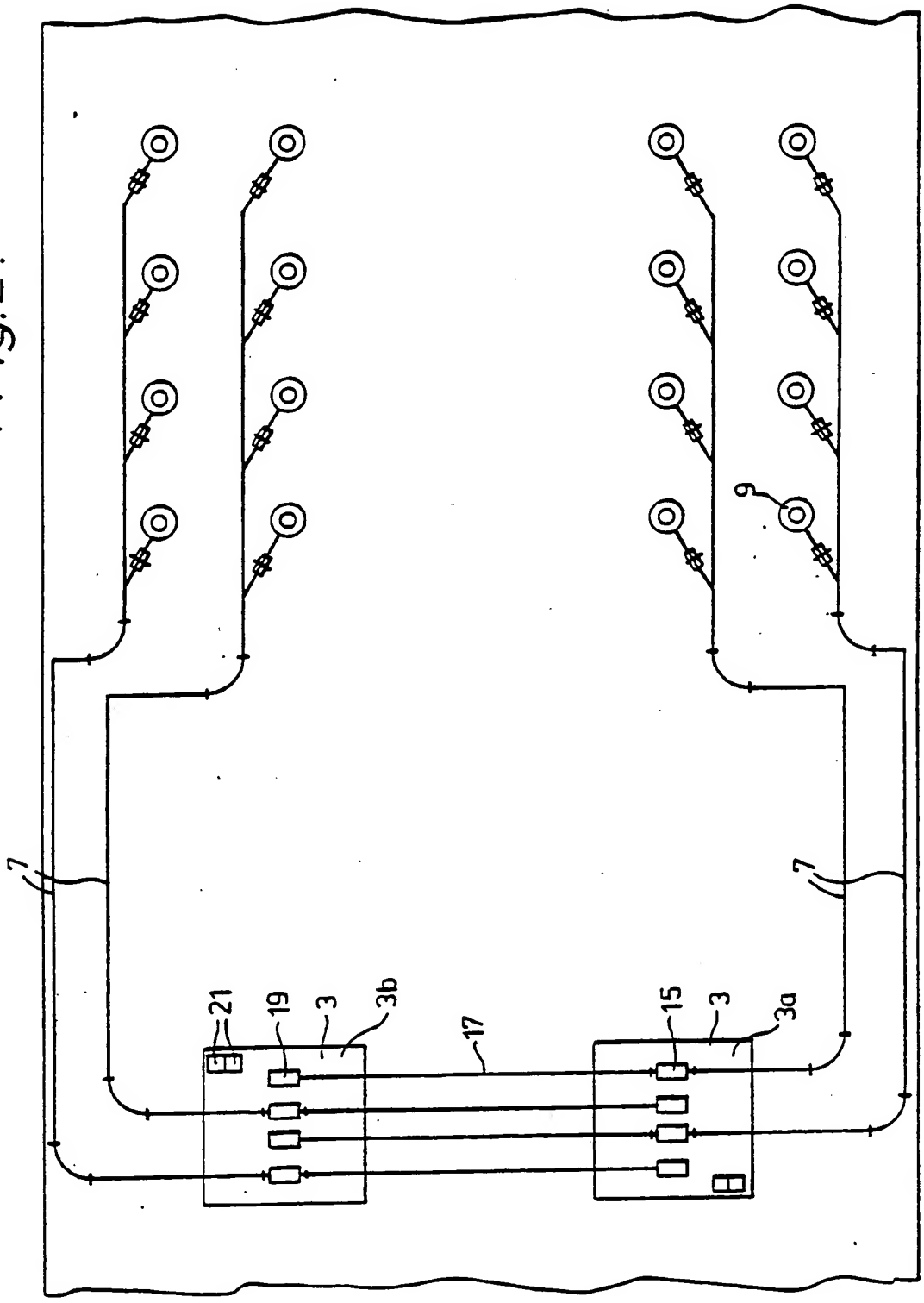


Fig.1.

Fig.2.



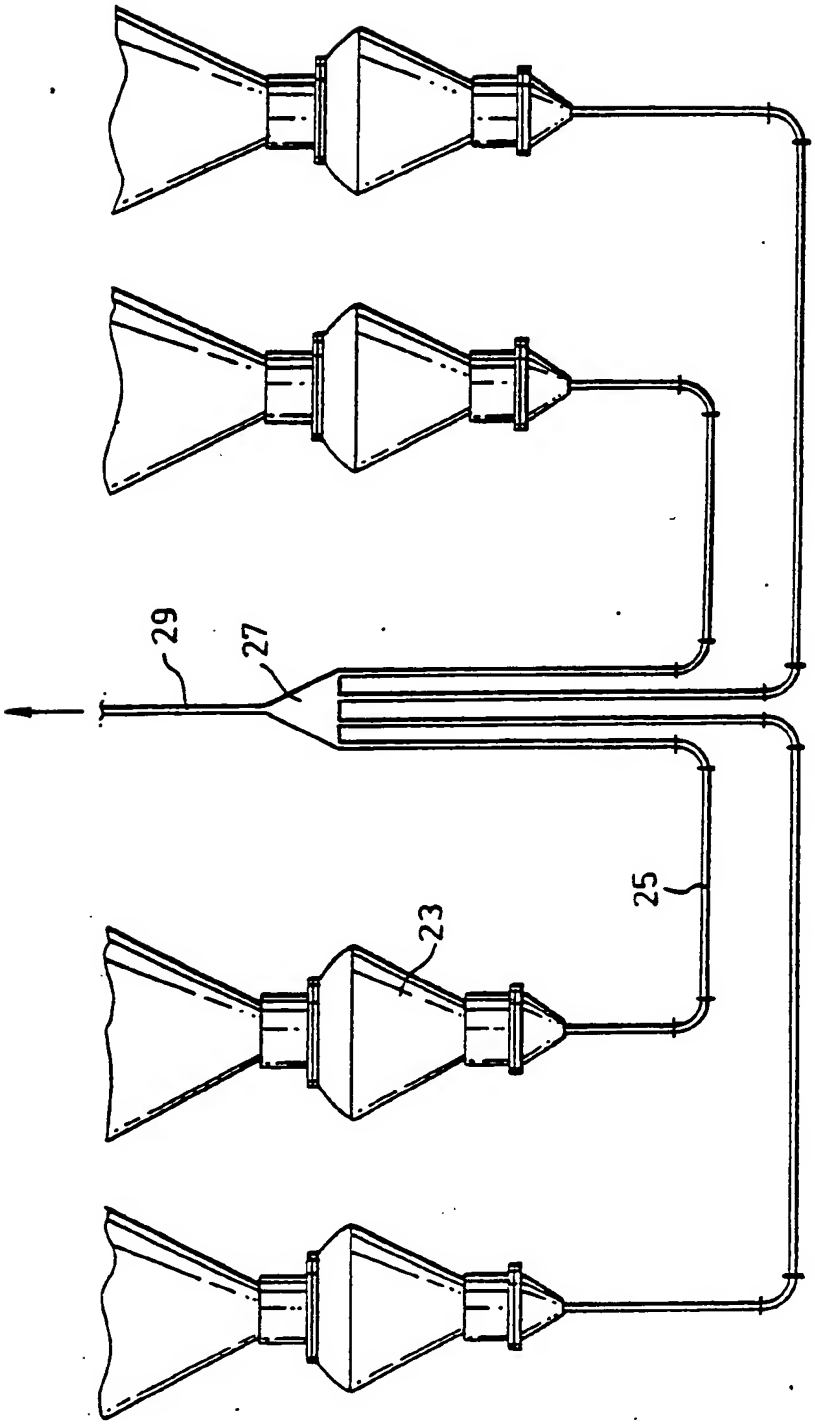


Fig. 3.

Fig. 6.

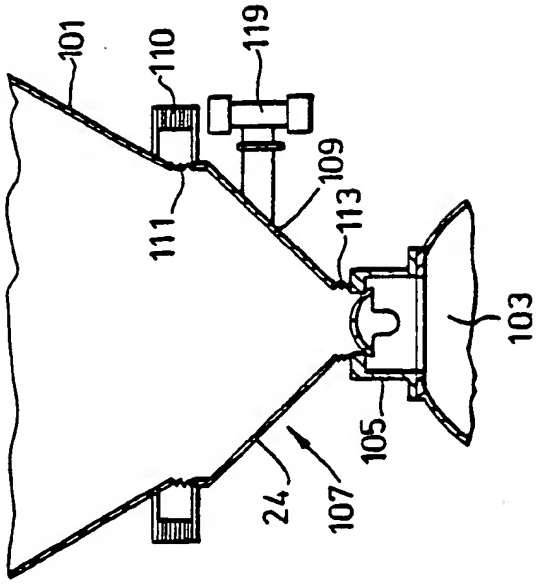
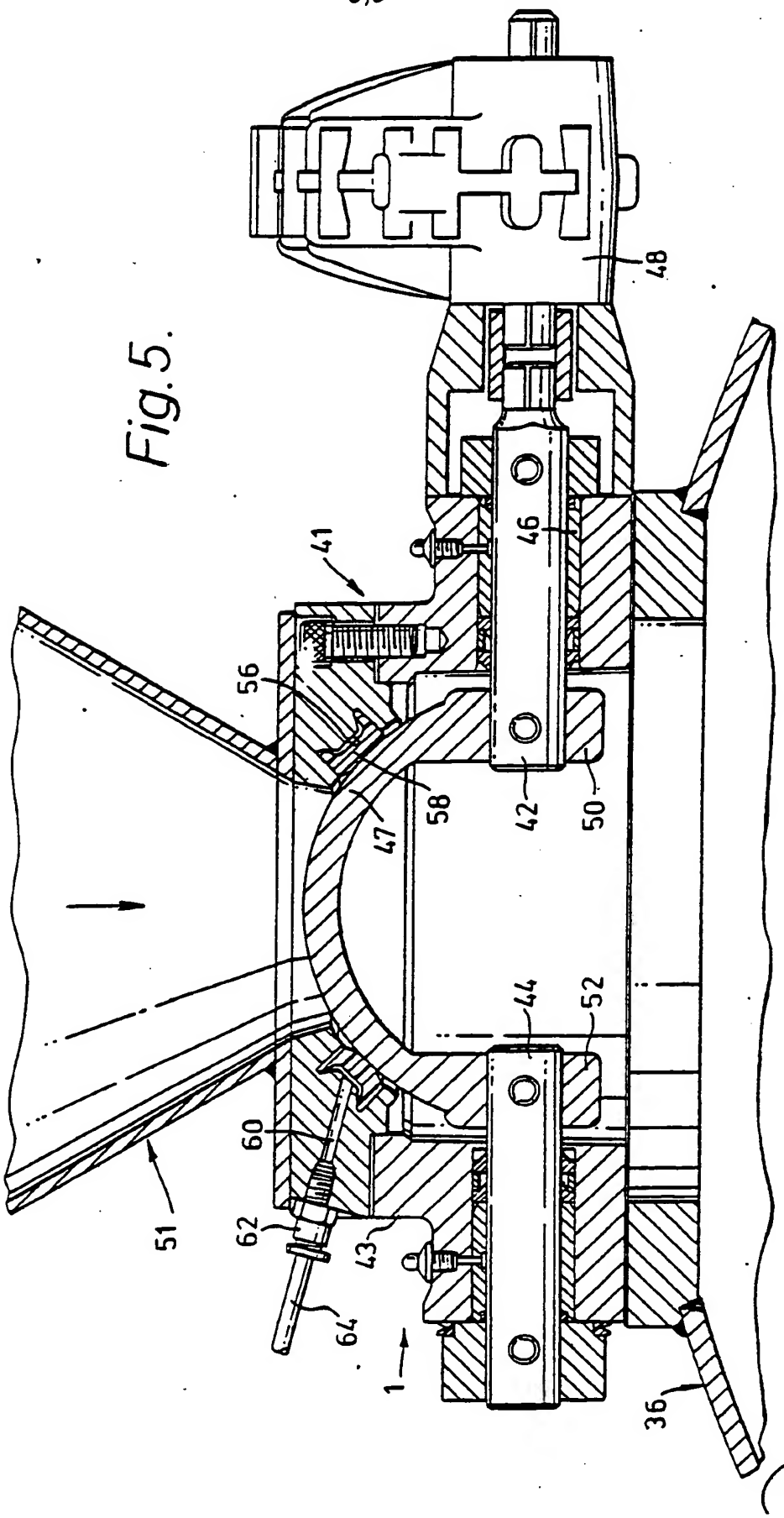


Fig. 4.

Fig. 5.



INTERNATIONAL SEARCH REPORT

International Application No PCT/GB 80/00145

I. CLASSIFICATION OF SUBJECT MATTER (if several classification symbols apply, indicate all) [3]

According to International Patent Classification (IPC) or to both National Classification and IPC

Int.Cl.[3]: B 65 G 53/12; B 65 G 53/46

II. FIELDS SEARCHED

Minimum Documentation Searched [4]

Classification System [5]	Classification Symbols
Int.Cl.[3]	B 65 G

Documentation Searched other than Minimum Documentation to the Extent that such Documents are included in the Fields Searched [6]

III. DOCUMENTS CONSIDERED TO BE RELEVANT [14]

Category *	Citation of Document, [16] with indication, where appropriate, of the relevant passages [17]	Relevant to Claim No. [18]
X	US, A, 4111492, published September 5, 1978, see column 7, line 26, column 8, column 9, lines 1-24, figures 1,2, Mraz	1-4,6,11
X	DE, A, 2149262, published April 5, 1973, see pages 3,4,5, figure 1, Waeschle	1-4,6,7,11
X	DE, C, 710526, published August 7, 1941, see page 2, lines 76-122, page 3, lines 1-22, figure 1, Polysius	1-4,6,11
X	DE, C, 482402, published August 29, 1929, see page 1, lines 23-63, figure 1, Polysius	1,2,5,11
	FR, A, 2314121, published January 7, 1977, see page 5, lines 14-40, page 6, lines 1-15, figure 5, Macawber	8,9

* Special categories of cited documents: [15]

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IV. CERTIFICATION

Date of the Actual Completion of the International Search [1]	Date of Mailing of this International Search Report [2]
May 6, 1981	May 26, 1981

International Searching Authority [1]	Signature of Authorized Officer [20]
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